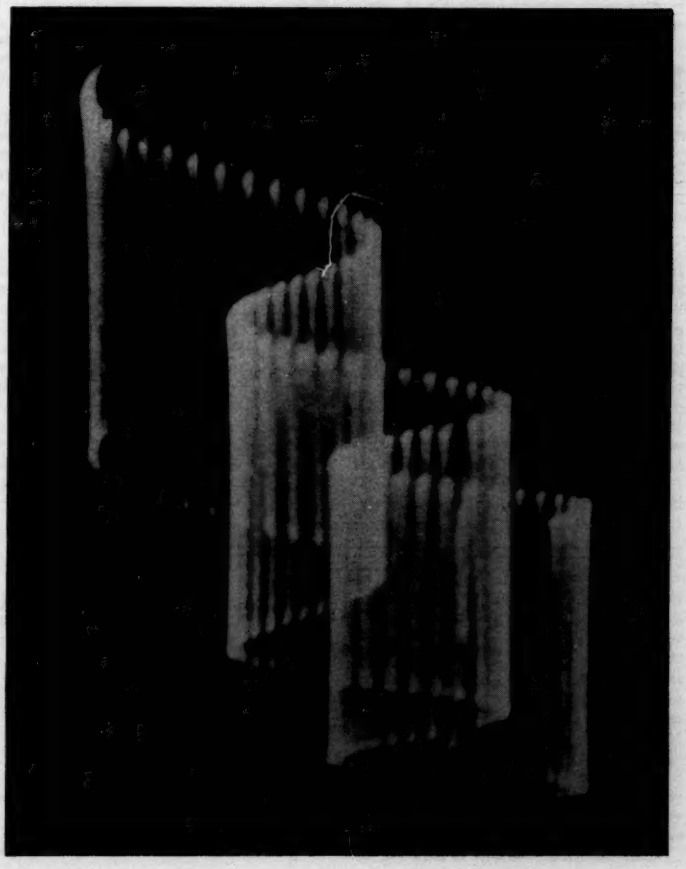
STATE ENGINEERING EXPERIMENT STATION

The Research Engineer

GEORGIA INSTITUTE OF TECHNOLOGY

SEPTEMBER ATLANTA, GEORGIA 1950



The Research Engineer

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MILITARY RESEARCH

In these days of international turmoil, every research organization deems it "part of the game" to aid national preparedness in every possible way. Industrial research organizations, mindful of the lessons of World War II, are continually developing new processes and products which are potentially of military significance. The efforts of the research divisions of government agencies are now well correlated with those of divisions of the Armed Forces, particularly as regards elimination of duplication of effort. As for the Armed Forces themselves, military research proceeds apace on rockets, guided missiles, jet propulsion, atomic bombs, long-range submarines, etc.

Most of this research for national defense is conducted in the laboratories and on the proving grounds created by the Armed Forces specifically for this purpose, but a large measure of it has been "farmed out" to those research establishments, public and private, whose facilities and staff especially equip them for the conduct of specific studies. These studies, in turn, vary widely in nature. Often, they are fundamental, basic studies of the properties of materials or the correlation of physical and chemical factors. They may concern themselves with strategic materials—with alternate methods of synthesis, upgrading of lean ores, or development of substitutes. Or they may be studies more directly concerned with materiel — with the nuclear sciences,

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"What is on the research horizons for tomorrow?" With that question on their lips, executives—industrial and governmental alike—look to the nation's research laboratories for their answer. In these laboratories, in turn, scientists and engineers look up from their work to inquire: "What do you want? New or improved products? New processes? Better tools? More economic sources of energy? New ways to kill? Tell us—give us what we need for the studies at hand—we'll do what we can. Or, if you will, let us proceed on some ideas of our own; we can almost guarantee a rich eventual harvest."

Where the research problem is clean cut, the engineer or scientist employs his education, experience, and "genius" to postulate one or more possible solutions and, by research, to arrive at the final answer—if one can be obtained. This process is not as simple as it may sound, nor as complex as the dazzled public would believe. It is the method by which science and engineering "earn their salt"—but it should not obscure the real need for the fundamental studies that may later answer undreamed of problems. Only by a proper balance between "industrial" and "fundamental" research can bright horizons be assured for tomorrow.

BLAKE R. VAN LEER

President, Georgia Institute of Technology

TELEVISION TODAY

By M. A. HONNELL*

Television has made amazing strides since THE RESEARCH ENGINEER, in 1949, published two articles on its status by Professor Honnell. Believing that this field of electronics is of interest and importance to everyone, this journal has accordingly again prevailed upon Professor Honnell to describe television as it is today, with cognizance of its future aspects. Georgia Tech research on this subject, especially as related to "three-dimensional" images, has already received much attention. The cover of this issue shows a three-dimensional cathode ray display obtained in current research.

Television's rapid growth into a billion-dollar-a-year industry in the short period of four years is a phenomenon of great economic significance. In spite of the Federal Communications Commission's "freeze" on new TV station applications, and the fear that future developments in the field of color television may render present sets obsolete, it has been predicted that over 8,000,000 television sets will be in use by the end of this year.

Manufacturers believe that a steady annual production of 5,000,000 television receivers will soon be reached, barring major armament interferences. The resulting stimulation to other industries is evident in current estimates that this rate of production of receivers will require approximately 100,000 tons of steel, 25,000 tons of copper, 20,000 tons of aluminum, 40,000 tons of glass, and 100,000,000 board feet of lumber—material which must be manufactured into the over 1,000 component parts which make up each television receiver.

In addition to the receiver business, millions of dollars are being spent on coaxial cable and microwave links which are rapidly interconnecting the major population centers of the country. For example, the Bell Telephone System is now completing a microwave link between New York

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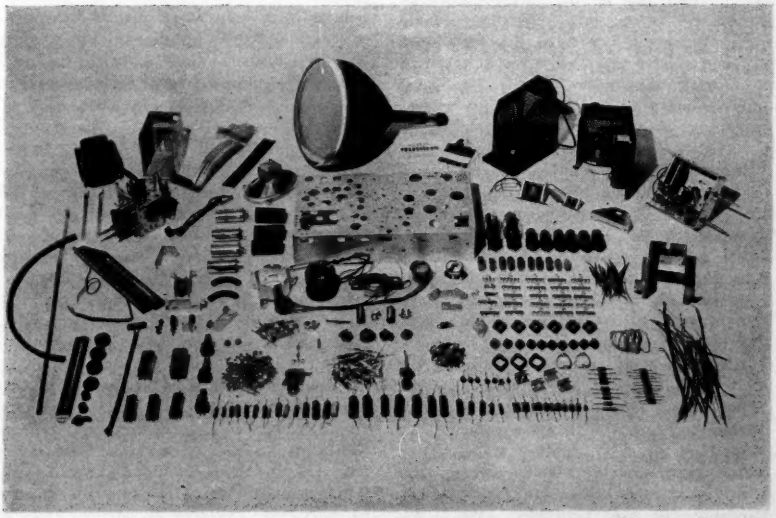

Figure 1. Over 1,000 parts make up the typical television receiver. (Courtesy of RCA.)

and Chicago which consists of over 30 radio relay stations; this link is part of a long range $70,000,000 construction program which will link more than 40 cities with 15,000 miles of television network facilities by the end of 1950.

Incidentally, the Bell System schedule calls for installation of 8,000 additional miles of network facilities in 1951, about equally divided between coaxial cable and microwave relay. By the end of 1951, the east and west coasts will be joined by a transcontinental link via Omaha and San Francisco. Western Union, moreover, has installed several microwave links employing equipment manufactured by Philco. One of these is a triangular link between New York, Pittsburgh, and Washington. Relay sites have also been selected by Western Union as far west as Minneapolis and Kansas City, and south to Atlanta. These links will provide circuits for facsimile message transmission as well as for intercity television.

The ultimate solution to the problems of sufficient bandwidth for high-resolution television and a sufficient number of channels to provide several network outlets in major cities lies in the establishment of microwave radio links. However, radio link installations are quite expensive, and it takes a long time to select and obtain appropriate station locations. The most suitable locations are sometimes on mountain tops, to which roads must often be provided before an installation may be made.

The average cost of equipment and facilities for a television broadcasting station is around $400,000. Moreover, the total investment for the 108 stations now in operation is far in excess of the $43,000,000 for equipment; to this figure must be added payrolls for talent, engineers, administrators, and the many others required for the operation of a TV station.

Although manufacturers are enjoying the TV boom, the financial picture is not "rosy" for everyone. Only a few broadcasters are beginning to make a profit. Of course, as the TV audience grows, more broadcasters will be able to charge rates which will permit them to make profits. However, the four networks, ABC, CBS, DuMont, and NBC, will have difficulty in getting out of the red until the Federal Communications Commission lifts its ban on the allocation of new stations. At the present time, there are not sufficient stations on the interconnected networks to warrant the high cost of coaxial cable and microwave link facilities.

There may be dangers, however, in taking for granted the fact that successful TV programming requires network facilities. Although immediacy plays an important part in television broadcasts of sports and current events, the general public does not object to a delay in viewing dramatic and musical shows. Programs recorded on films offer many advantages in that they may be edited; moreover, the use of films offers a wider range of program material than does direct TV broadcasts. There is even a strong likelihood that the networks will use film much in the same manner as they are now using tape recordings for distribution of radio programs.

It is believed that a new motion picture industry specializing in the production of short, low-cost films designed for TV broadcasting will soon develop; this may be the chief answer to the problem of TV programming. The size of this potential film industry may be envisioned from estimates that 5,000 hours per year of film will be required, compared with the total present Hollywood output of feature films and shorts of 650 hours annually.

LEGAL ASPECTS

There are at present 106 television stations on the air on channels 2 through 13 in the Very-High-Frequency (VHF) band from 44 to 88 and 172 to 216 megacycles. The Federal Communications Commission will probably provide 40 additional channels in the Ultra-High-Frequency (UHF) region between 480 and 920 megacycles. The present allocation plan is designed to provide at least one television outlet to each part of the United States and at least one television station to each community. In other words, first priority has been assigned to coverage on an area basis rather than on the basis of population density. This plan is causing considerable chagrin in television broadcasting circles, since it is believed that frequency assignments will

be wasted on small communities financially unable to support even single television stations.

Manufacturers are anxious for the Federal Communications Commission to lift its long freeze on the new allocations, because the opening of television channels in 1,400 cities and towns in the proposed allocation table would provide new markets for many years. Actually, they have benefited somewhat from this freeze, in that they have not had to overexpand their production facilities and can now expect continuing high-level markets. Moreover, many potential TV broadcasters who applied for a TV channel before the freeze have welcomed the reprieve from a business which is only now beginning to show profits for a few stations.

The delay of the FCC in lifting its freeze has been occasioned by several important factors concerned with the commission's desire to provide a maximum television service to the public in the available frequency channels. This delay has been augmented by the lack of information concerning radio propagation conditions at the higher frequencies. Added to this is the problem of developing stable receivers and transmitters with sufficient power to provide the desired television coverage at these frequencies. Petitions by the Columbia Broadcasting System for the establishment of color television standards at this time have further clouded the issue. It is believed generally that the freeze was necessary; there is considerable debate, however, concerning the advisability of its long continuance.

COLOR TELEVISION

Sometime in the not-too-distant future, color television will cease to be in the "just around the corner" stage. Largely due to the request of the Columbia Broadcasting System that the FCC establish color television standards in the VHF band, considerable progress has been made in the field of color television by various groups anxious to have their particular developments accepted as standard. Color television systems have been demonstrated to the FCC by CBS, RCA, and Color Television, Incorporated.

The CBS system is a field sequential system employing 405 scanning lines per frame, interlaced two to one. The scene to be transmitted is picked up by a single camera lens and is passed through a rotating color filter synchronized with the field frequency so that the green components of the scene are transmitted for 1/144 of a second, then the red and the blue components are each transmitted for 1/144 of a second. Therefore, a complete picture containing all of the basic color components is transmitted in 1/48 of a second. A similar color filter at the receiver rotates in synchronism with that at the transmitter, and the scene appearing on the face of the kinescope is viewed through this color filter. The picture quality of the CBS color system is excellent, but present receivers would be unable to receive the CBS color transmissions in black and white unless circuit modifications were made.

It is generally conceded that the CBS color system is completely practical and offers advantages of simplicity at the studio and receiver. However, it is believed that the rotating disc has disadvantages which make this system undesirable as a permanent standard.

The color television system developed by CTI is a line sequential system in which successive lines are scanned in the red-green-blue sequence. Since this system employs the same standards as the present black-and-white system, it permits a monochrome version of the color transmissions to be received on existing receivers. Among the several disadvantages of the CTI system, however, are the fact that it requires three separate optical systems at the receiver to project three separate color images in precise register on a viewing screen. This type of receiver is both expensive and difficult to maintain in adjustment.

The most recent version of the RCA color receiver demonstrated to the FCC employs a tricolor kinescope which permits the direct receiving of color pictures on its screen. This screen has minute red, green, and blue phosphor dots arranged in an orderly array of triangular groups which are bombarded by the electron stream, either from a single electron gun or from three separate electron guns in the two types of

tubes currently demonstrated. The RCA color dot sequential system employing a 6-megacycle bandwidth and regular black-and-white standards appears to hold the key to an inexpensive color receiver. Furthermore, these color transmissions may be viewed in monochrome on existing receivers without circuit modifications.

The compatibility of a color system with existing standards is very important, because it permits the existing black-and-white service to be expanded without regard to color problems. Then, when a TV broadcaster institutes use of a color system, he can offer both color and monochrome service without a loss of audience. At best, however, the cost of color broadcasting is high, and very little color film is at present available for television use.

Little mention has been made of cameras for color television broadcasting. Those cameras demonstrated to date are either too bulky, have a narrow field of view, or lack the high light sensitivity of standard monochrome cameras. However, these cameras are adequate for color film pickup, and future research will undoubtedly yield decided improvements in quality.

INDUSTRIAL TELEVISION

The nonentertainment applications of television may eventually grow into a service of much broader scope than the television broadcasting system of today. It has already been readily appreciated that television is an extension of human sight, and as such that it may view a scene or process which is inaccessible or dangerous to humans. In order for television systems to be widely used in such situations, however, it is desirable that the equipment be reliable, compact, and inexpensive.

Industrial television systems have been recently demonstrated by the Diamond Power Specialty Corporation of Lancaster, Ohio; by DuMont; and by RCA. The RCA equipment is of particular interest, because of its miniature camera tube, the Vidicon, which is mounted in a camera 10 x 5 x 3¼ inches and which weighs only eight pounds. The standard 16-millimeter motion picture lens used with the Vidicon is focused by remote control from the receiver monitor, which is 24 x 15 x 8½ inches and weighs 58 pounds. The camera and monitor are connected by a multiconductor cable which may be 500 feet long. The complete system contains less than 50 tubes and consumes approximately 350 watts of 115-volt, 60-cycle power.

A special version of this equipment provides three-dimensional stereoscopic vision. Two cameras mounted side by side, the same distance apart as the human eyes, view an object from slightly different angles, and the pair of resulting signals are then viewed over two separate kinescopes through a lens stereoscope. This system offers particular advantages where remote manipulative operations are to be performed with remote-controlled, servomechanism-operated artificial hands.

The many applications of industrial television equipment are too numerous to describe in detail. CBS has demonstrated to the medical profession the advantages of its color system for viewing surgical operations in full color at a remote point. RCA has mounted its Vidicon camera on a microscope and demonstrated how a large group of students may view microscopic events on a large kinescope screen. The Diamond Power Specialty Corporation's "Utiliscope," for example, is advertised for use "wherever it is too dangerous, too difficult, too expensive, too inconvenient, too inaccessible, too tiring, too far, too hot, too cold, too high, too low, too dark, or too small to observe directly." An application engineer in the field of industrial television may truly let his imagination run wild.

TECHNICAL ASPECTS

Many technical changes have been made in television receiver designs during the past year. These changes have enabled manufacturers to sell sets equipped with 12-inch and 16-inch kinescopes for the same price as the 10-inch receiver of 1949. This reduction in cost was brought about in part by less-expensive cabinet designs. However, the use of the inter-carrier system for the audio channel along with a narrowed video bandwidth are responsible for the greater part of the price decrease. However, these changes have often resulted in receivers with

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THE STATE ENGINEERING EXPERIMENT STATION 1949-1950

By GERALD A. ROSSELOT* *and* FRED W. COX, JR.**

The past fiscal year was one in which the Station progressed is many ways. The following article has therefore been prepared in an effort to depict this progress in some detail and to reemphasize the Station's purposes and aims.

For the Georgia Tech Engineering Experiment Station the fiscal year 1949-1950 was marked with progress, expansion, and accomplishment. Research for industry and government reached new heights; new laboratories, facilities, and services were provided for sponsors of research projects; new scientific personnel were added to the staff; new fields of research and development were investigated.

Emphasis was placed on integration, selected expansion, and increased service to industry. Research operations have been organized into three cooperating divisions: chemical sciences, mechanical sciences and physics. Other internal operations have been consolidated so that the Station can offer better service to its sponsors, to Georgia Tech, and to Georgia.

While the past year saw expansion in Station activities in all fields of its endeavors, of particular note has been increased research in the fields of chemistry, electronics and machinery development. A growing demand, from a research standpoint, has forced expansion of facilities in the fields of micromeritics, protective coatings, electronics, physics, engineering design and development, and underwater engineering. Completion of the new wing of the Research Building will supply much needed space for offices and laboratories.

BUDGET

Continuing the trend of recent years with regard to its service to industry and government, the State Engineering Experiment Station, on June 30, closed its books on one of the most successful years of its existence. Despite the loss of some $90,000 in research operational funds that were normally provided by the State of Georgia (through the Board of Regents and the Georgia Institute of Technology), the Station's total budget for direct expenditures for the fiscal year was $582,000, not far below the $618,000 expended during 1948-49.

This level of activity was made possible by the acceptance of a number of new research projects, renewal of old projects, and the support of certain fundamental research projects by the Georgia Tech Research Institute. Of the Station's operational budget, 89.2 per cent was derived from contract research activities through the Georgia Tech Research Institute, 1.9 per cent came from special grants and endowments, 8.5 per cent from grants-in-aid and cooperative projects, and 0.4 per cent from a special grant from the Board of Regents.

PERSONNEL

The diversified research program of the Station required, on the average, the full-time services of 78 persons and the part-time services of more than 100 others. Of these, 33 were faculty research associates; two, research professors; three, research associate professors; one, research instructor; 16, research engineers; 33, research assistants; and the balance, technical assistants and clerical and office personnel.

Expanding activities have required the Station to strengthen its organization by the creation of three technical divisions in the fields of chemistry, mechanical engineering, and physics. To head up its Chemical Sciences Division, the Station has been fortunate in acquiring the services of Dr. Herschel H. Cudd, Ph.D. in Physical Chemistry from the University of Texas. Dr. Cudd brings with him considerable industrial experience in chemistry and textiles, obtained at E. I. du Pont de Nemours &

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**Assistant Director.

Company, The International Minerals and Chemical Corp., and the West Point Manufacturing Company, for which latter organization he was director of the Lantuck Division. Dr. James E. Boyd, for several years Professor of Physics on the staff of the Georgia Tech School of Physics and Faculty Research Associate to the State Engineering Experiment Station, has been promoted to head of the Station's new Physics Division. Dr. Boyd received his Ph.D. in Physics from Yale University. A highly capable scientist in the field of electronics, mathematics, and physics, he has served as project director for two of the Station's largest projects. It is expected that a comparable scientist will be obtained in the near future to head the new Mechanical Sciences Division.

Added to the research staff during the year were: industrial engineers and economists, Maurice R. Brewster, W. A. Flinn, W. J. Hillyer, and W. D. Kerr; chemists, Dr. W. C. Whitley, William Brogan, Richard R. Cornwall, Susan L. Craig, Marjorie Ann Maertz, Agnes C. Redfearn, Peter B. Sherry, and Grant Allen; chemical engineers, Ben Carmichael, Robert A. McAllister, and William F. Zinoni; biochemist, Edward L. Fincher; aeronautical engineer, Noah C. New; hydraulics engineer, Harold R. Henry; textile engineer, Vernon C. Thompson; electrical engineer, Maurice W. Long; and physicist, Fred Dixon.

In 1949-1950, the Station's staff participated in the activities of numerous technical or scientific organizations and committees. Also, over 50 talks or papers on technical or semi-technical subjects were made before over 38 interested outside organizations. The Director of the Station received outstanding off-campus recognition by being elected chairman of the Engineering College Research Council and chairman of the Research Section, Engineering Division, Association of Land Grant Colleges and Universities. In addition, Dr. W. T. Ziegler was chosen chairman-elect of the Georgia Section of the American Chemical Society; W. J. Miller was elected chairman of the local section of the Institute of Radio Engineers; Dr. J. M. DallaValle presented an invited paper before the U. S. Technical Conference on Air Pollution in Washington, which conference was called by President Truman; and Dr. R. S. Ingols presented an invited paper before the Symposium on Water Sterilization sponsored by the Institute of Water Engineers at Leeds, England. B. H. Weil has been appointed editor of *Chemical Literature*, the new bulletin of the American Chemical Society's Division of Chemical Literature; he also serves on that division's program committee.

On March 21 and 22, 1950, the Office of Naval Research held its Cryogenics Conference at Georgia Tech under the co-chairmanship of Dr. Ziegler. Over 60 leading scientists in this field from 24 institutions convened for discussion of the latest developments in low-temperature research.

FACILITIES

The outstanding new facility to be added to the Station during the year is the new wing of the Research Building, construction of which was made possible by the Hinman Fund, a grant from the Georgia Institute of Technology, and other gifts. Although this wing will not be ready for full occupancy until the fall of 1950, partial occupancy was scheduled for August. This new construction, adding approximately 20,000 square feet of floor space, will provide much needed laboratories, offices, and conference rooms.

Acquisition of a considerable amount of new equipment during the year has contributed materially to the Station's permanent facilities. Equipment ordered last year for the Coatings Laboratory has arrived. This laboratory has been located in a small building behind the main Research Buildings and is now in operation on several research projects.

The Micromeritics Laboratory has built a low-temperature gas adsorption apparatus and an arealometer and has acquired a micropulverizer, a colorimeter, a phase microscope with accessories, interfacial tensiometers, an electronic settling rate instrument, a supercentrifuge, a ball mill, an electric titrimeter, and a chlorine determination apparatus.

Investigations of the effect of weather on microwave propagation have been facili-

tated by new automatic recording equipment for measurements of temperature and humidity at 10-foot intervals to a height of 100 feet. Millimeter band equipment added in the microwave laboratory includes a narrow bandwidth, high-gain amplifier designed and constructed for use as a video-type receiver in the detection of low-level microwave signals which are modulated at five kc. A low-level atmospheric sounding system also has been developed and is available for further studies of atmospheric physic.

Research in the field of aeronautics has been aided by improvements to the pilot supersonic wind tunnel and to the Schlieren apparatus. Electrical probe depth indicating equipment has been improved, as have also the model supporting system and angle-of-attack adjustment provisions for the experimental water channel.

For one research and development project, an oscillograph trace intensifier has been developed which causes a brightening of the oscillograph trace during periods of rapid writing rates, thus permitting obtainment of more uniform photographic film densities over a wide range of writing rates. To allow for simultaneous display of two transient signals on a cathode-ray oscillograph. an electronic switch was designed and constructed. The switching frequency was set at 250 kc per second so that five samples of each signal would be taken in 0.02 millisecond. For another project, the Experiment Station has leased a 15-acre tract of land, including an eight-acre lake. Four small prefabricated buildings and special test rigging have been erected for the purpose of carrying out field tests required in this project's development work. With the completion of certain facilities for use on a National Institutes of Health project, a complete bacteriological unit will be added to the Station.

For research on peanut handling, one project has acquired a small-size peanut sheller and other specialized equipment for cleaning farmer-stock peanuts. Also, a semi-microanalytical laboratory has been established and equipped for use on a project dealing with special analyses of beryllium and its compounds. Some of this equipment may later be used on radioactive tracer work.

A pilot fluidized catalysis unit has been constructed; this is suitable for the study of the distillation of a variety of carbonaceous materials such as hard and soft woods, coals, and peats, and for other catalytic techniques.

In addition to these items, other equipment obtained by the Station during the past year includes: an 8-point temperature-control recorder; microhardness testing equipment, for use in the study of alloys; an air-tight chamber for infiltration and strength studies on windows; and new soil-load test equipment. A television receiver was modified to demonstrate new velocity modulation principles discovered in television research.

RESEARCH FOR THE STATE OF GEORGIA

As was noted above and as may be noticed later in this paper, the Station is increasing its services and value to industry and to agencies of the federal government. However, one of the Station's major functions—as charged by its creators, the 1919 Georgia Legislature—is the undertaking of research in the interests of the State of Georgia for the development of natural resources and the promotion of new industry. Because of the failure of the State to provide operating funds for this purpose through the Board of Regents, research of this nature has drawn to a virtual standstill during the past 12 months. Since Georgia—its industry and its economy—is badly in need of research of this type, it is sincerely to be hoped that funds will be provided not only to continue but actually to expand this valuable service. However, no such prospect is evident at this time for 1950-1951.

SERVICE ACTIVITIES

Although its work has been curtailed somewhat because of the inability of the Georgia Institute of Technology to provide the Station with operating funds from its allotment from the Board of Regents, the Technical Information Division was able throughout the year to furnish its unique services in all cases of need. Its publication

program, however, has suffered, and will continue to suffer until adequate funds are forthcoming.

On the other hand, because their services are largely reimbursable from project funds, the Station's Machine Shop, Engineering Design Section, and Photographic and Reproduction Laboratory have continued to expand the scope of their functions. The Machine Shop has taken on more complicated jobs in the form of construction of automatic machinery; the Engineering Design Section has added a full-time mechanical engineer; and the Photographic Laboratory is now offering complete layout, Vari-Type, and Multilith services.

The Technical Information Division and the Photographic and Reproduction Laboratory have recently expanded their activities to include more sponsored projects. Through the entire year the Technical Information Division has prepared (and the Photographic Laboratory has published) a "Monthly Summary of Industrial Developments," a 20-30 page, monthly digest of industrial developments related to petroleum processing. This publication has enjoyed an enthusiastic reception. Over 385 copies are now being received by eight sponsoring companies.

The Photographic Laboratory has made a high speed photographic study of action of the pickerstick check strap on the X-2 Draper loom. This motion picture has evoked considerable interest.

PUBLICATIONS

Progress reports on a number of the Station-sponsored projects as well as special reports on other Station activities have been published in the scientific and technical journals or have been issued as circulars or bulletins of the Station. During 1949-1950, members of the staff were credited with 26 publications. Of these, two appeared as circulars, 11 as papers in technical journals and the organs of technical societies, and 13 as articles in THE RESEARCH ENGINEER. Of particular interest was a request by the Signal Corps for permission to reprint for general distribution Dr. W. A. Edson's project report on "The Keying Properties of Quartz Crystal Oscillators."

These publications do not represent all of the Station's progress reports, since much of its work is of a confidential nature and does not lend itself to publication at this time. In addition to the above publications, the Station has continued to prosecute patent applications previously filed and has aided sponsors in their patent work.

For the third consecutive year, papers published by members of the staff of the Station on work sponsored through the Station have been awarded the Georgia Tech Sigma Xi Club's First Faculty Prize for the best Georgia Tech research paper of the year. The award for 1949-1950 went to T. W. Kethley, Dr. F. Bellinger, and W. B. Cown for four papers: "New Test for Gaging Leakage from Frozen Fruits and Berries," which appeared in *Food Industries* (*21*, No. 2, 192-95, 209, 210); "Freezing Time-Leakage Relationship for Strawberries," which was published in *Food Industries* (*22*, No. 1, 58-60); "An Estimate of Thermal Conductivity of Fruits and Vegetables," which was printed in *Refrigerating Engineering* (*58*, No. 1, 49, 50); and "Measurement of the Color of Foods," which appeared in THE RESEARCH ENGINEER (*1949-1950*, No. 2, 5-8, 21, 22). The second faculty prize for 1949-1950 was awarded to W. H. Burrows for his Station-sponsored paper on "Graph Papers as Instruments of Calculation," which was published in *American Journal of Physics* (*17*, No. 3, 114-26).

During the year, the Station's new brochure, "Research at the Georgia Institute of Technology," was prepared and published. This is a 36-page booklet which describes in a general way, through pictures and brief descriptions, the facilities and capabilities for research at Georgia Tech. Copies are available on request.

RESEARCH OPERATIONS

Some 19 major projects were inaugurated in 1949-50, together with 49 projects of lesser magnitude. It is particularly significant to note that many projects under study prior to July 1, 1949, continued during the past year, thus giving the Station considerable work stability.

In all, over 112 different projects have been prosecuted during the year, a total

which represents a gain of 42 over the previous year's operations. Three fundamental projects of considerable interest to the State of Georgia were financed by a special grant from the Georgia Tech Research Institute, as approved by the Station's Faculty Advisory Council. Almost all of the other projects were conducted with funds provided by outside agencies including the Armed Services, cooperating and governmental agencies, individuals, and private industries. Extensive research programs relating to industries, natural and agricultural resources, and fundamental problems were actively pursued.

Brief summaries are given below for some of the projects in which the Station was engaged during the 1949-1950 year. Description of those projects in which specific sponsors are named are included here with their permission. Summaries for certain other projects could not be included because of their confidential nature.

Among the major projects, one deals with the handling of peanuts; another with a physical study of paint systems; and others with a study of reinforced brick masonry, physical characteristics of foods, an oil-extraction process, the effect of low temperatures on microorganisms, special analytical problems connected with beryllium, dielectric and reflecting properties of sea water at microwave frequencies, a physical study of yarns, and the development and construction of an automatic toy assembly machine. Extensive research continues to be performed for Governmental and military agencies, in connection with their research efforts. In addition, several new wind tunnel studies were undertaken during the year for airplane manufacturers.

During the year, also, considerable additional assistance was rendered to Georgia industries and others in the way of provision of technical information and advice, through conferences and correspondence. Such activities constitute a vital part of the Station's research service efforts.

CHEMICAL SCIENCES DIVISION

CHEMICAL RESEARCH

Very Low Temperature Research. Sponsored by the Office of Naval Research, this project has for its objective the investigation of the electrical and magnetic properties of substances at very low temperatures (1.5 to 20° K.) with a view toward discovering possible new superconducting substances. A study has been made of the conditions under which lanthanum metal can be converted from the hexagonal close-packed (h.c.p.) to the face-centered cubic (f.c.c.) structure. It has been found that lanthanum filings may be readily converted to the f.c.c. modification, but that this is apparently not the case for bulk specimens. Work has also included the preparation, by means of ion-exchange techniques, of multigram quantities of praseodymium and neodymium oxides having a purity greater than 99.5 per cent.

Further work will be performed on the relation of structure to superconductivity in lanthanum. Lanthanum metal and lanthanum nitride and hydride, prepared here, will be examined for superconductivity and for crystal structure. Studies of the variables governing the separation of praseodymium and neodymium oxides from each other and from lanthanum will be continued.

Fundamental Battery Studies. This project, sponsored by the Battery Branch of the U. S. Army Signal Corps, was completed during the year. It dealt with the development of a method for the electrochemical synthesis of a superior battery-active manganese dioxide. A satisfactory process was developed here and carried through the semi-pilot-plant stage. A final report on theoretical and technical aspects, rendered to the sponsor, has invoked considerable interest from battery manufacturers and allied chemical companies.

Surface Properties of Fine Particles. Conducted for the U. S. Signal Corps Engineering Laboratory, this research has as its objective an investigation of the surface properties of fine particles as related to particle surface area and particle size distribution. Particle surface area measurement techniques in general use have been tested and found to give widely different results. A dye adsorption technique has been developed which generally gives surface area

values intermediate to those of the other methods. This new technique is believed to offer decided advantages over the other methods for many purposes. An electronic instrument for indicating particle size distribution by recording the settling rate of particles in liquid suspension was built and has proved to be a considerable improvement over other methods of determination.

Future work will be concerned with improving the dye adsorption method for determining surface area and the settling rate method for particle size distribution. The effect of various acid and heating treatments on surface area and adsorptive capacity will be investigated.

Additional Fine Particle Studies. Another project in the field of micromeritics has dealt with the settling rate of particles in air suspensions. Theoretical equations governing the laws of settling and indicating useful parameters for correlations have been developed. Future plans include work to obtain additional information on particle settling rates and particle dispersion. The value of the various theoretical equations in correlating the data will be investigated.

Special Analytical Problems. Highly specialized analyses on beryllium and its compounds have been undertaken for the NEPA Division of the Fairchild Engine and Airplane Corp.

Titanium Alloys. In a project sponsored by the Station, titanium-base alloys containing up to 5 per cent copper are being investigated in a study of the solid solubility limits of copper in titanium and the effect of copper on the allotropic transformation of titanium. A suitable melting furnace has been designed for preparing approximately 0.25-pound melts under an inert atmosphere. Bergsman microcharacter hardness testing equipment will be employed. After information of the equilibrium diagram is obtained, studies will be undertaken on heat-treating prospects and modifications involving the use of additional elements.

Combustion Products. In cooperation with the Georgia Department of Public Health and under a grant from the National Institutes of Health, a study has been made on carbon monoxide formation in a small, tightly sealed room as a result of the use of vented and unvented gas heaters. Both natural gas and liquefied petroleum fuel were utilized in these experiments. It was found that lethal quantities of carbon monoxide accumulated in less than two hours when an unvented heater was employed. The Georgia Department of Public Health expects to utilize the data obtained for the purpose of formulating codes to regulate the use of unvented gas heaters in tourist cabins.

Vegetable Oil Studies. Small-pilot-plant experimentation on a water-grinding, centrifuging process for the simultaneous extraction of oil and protein from oilseed has confirmed the technical feasibility of this process. Work during the past year included studies of peanuts, tung nuts, cottonseed, and soybeans, all of which were processed with excellent yields and high-quality products.

It is expected that larger-scale pilot-plant operations will give oil yields which compare favorably with those obtained by solvent extraction and that the protein obtained will be of high quality. The economic feasibility of the process will be further investigated. Being Station sponsored for the benefit of the State, this project has suffered considerably from the previously mentioned lack of State funds. However, it has been supported in part by a special grant from the Georgia Tech Research Institute.

FOOD RESEARCH

Preservation of Foods by Freezing. The past year's objective for this project, jointly sponsored by the Station and the Tennessee Valley Authority, has been the determination of means of specifying and establishing standards for the color of foods. Studies on the analysis of the color of green vegetables have indicated that it should be possible to devise a relatively simple instrument for the grading of color of such vegetables. This apparatus would permit the definition of market grades and the quality control of processed green vegetables. It is hoped that, during the coming year, continued research will include a study of fruits and berries.

Physical Characteristics of Foods. Sponsored by the Experiment Station, this project has had for its objective the study and development of methods to determine the physical changes in foods caused by freezing and storage while frozen. A study of methods for determining texture changes in vegetables has shown that no single method is adequate for this purpose. Studies on the quantitative analysis of leakage in fruits and berries indicate that there is a possibility that a significant shift in the location of water within the tissue occurs prior to thawing, perhaps during freezing storage. If funds permit, this work will be continued in the future.

COATINGS RESEARCH

Physical Studies of Paint Systems Applied to Southern Yellow Pine. Sponsored on a cooperative basis by the Southern Paint and Varnish Production Club, this project deals with the improvement of paint durability and appearance on southern yellow pine by comparative evaluation, after exposure on test fences, of: (1) paint formulations in wide usage today, (2) variations of these formulations, and (3) experimental formulations embodying new ideas and materials. A number of primer and top-coat formulations have been prepared and are now being tested by exposure. Additional formulations of an experimental type are being prepared.

Exposure studies are necessarily a long-range project. Thus, three or more years of exposure will be required before evaluation of the above-mentioned paint systems is complete. Also, repaint studies of the exposed systems may extend the program several additional years.

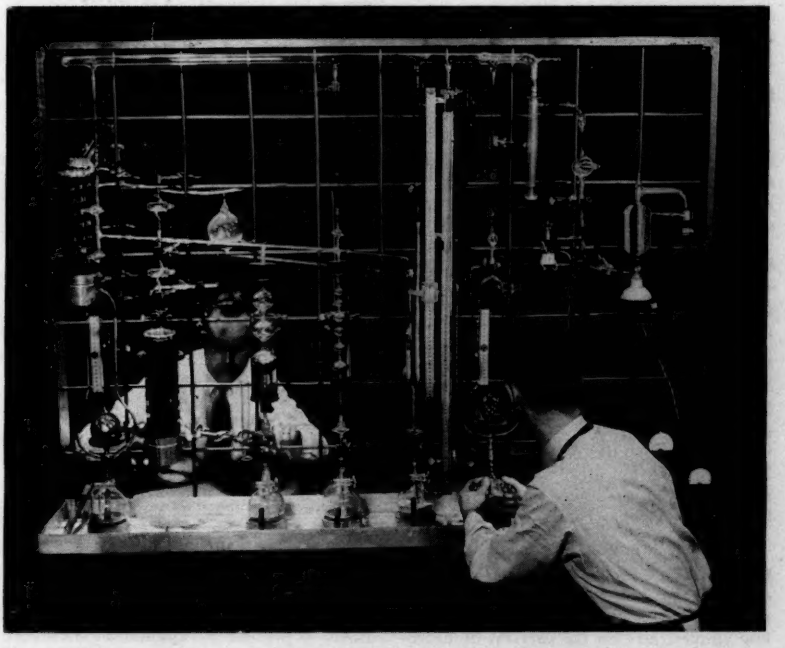

Figure 1. Fine particle research involves the study of such properties as surface area. Shown here is the Micromeritics Laboratory's B-E-T apparatus, one of the devices used for this purpose.

Varnishes. For an industrial sponsor, a study was made of the physical properties of varnishes for wood.

Resins. For another industrial sponsor, a study is being made on the use of special resins in paint and coating formulations. This work involves formulation, testing, and outdoor exposure.

Flooring. One project calls for the formulation and evaluation of special flooring materials and is being undertaken for an industrial sponsor.

WOOD RESEARCH

Wood Distillation. Operability of the Georgia Tech process for applying the so-called fluidized powder technique to the distillation of wood has been confirmed. Sound data on rates of distillation and yields of methanol and acetic acid have been obtained to serve as a basis for economic studies.

TEXTILE RESEARCH

Physical Study of Yarns. Research is being conducted for the Air Materiel Command of the U. S. Air Force on establishment of the physical characteristics of new yarns such as rayon, nylon, orlon, and vinyon. A thorough study is being made of the effects of twist on yarn strength.

Fabric Analysis. For an industrial sponsor, an analysis was made of his special fabric products in comparison with competitive products.

Miscellaneous. The reclamation of cotton-card fly was studied for Southern Mills, Inc. A slow-motion (high speed) photographic study was made, for the Textile Leather Division of the American Leather Belt Association, of the action of the pickerstick check strap on the X-2 Draper loom.

BIOCHEMICAL RESEARCH

Effect of Low Temperatures on the Survival of Microorganisms. The purpose of this project is the determination of the effect of low temperatures on the survival of microorganisms. A complete survey of the literature has been made and results applied to project planning; the findings of this literature search will be summarized and offered for publication. Efforts have also been directed towards the establishment of a method for the quantitative determination of survival rates of bacteria subjected to low temperatures. This work is being performed under a grant-in-aid from the National Institutes of Health.

Rapid Procedures in Water and Sewage Analysis. Continued investigations have been performed with a view toward the development of rapid procedures for the analysis of water and sewage, under a grant-in-aid from the National Institutes of Health. A major review paper on methods of measuring the strength of sewage has been published and has evoked much editorial comment.

Several manuscripts reporting results obtained on fluoride ion determination, problems in the determination of chromium, and sulfate ion determination by two distinct methods remain to be published. Two of these papers are in the hands of editors, and two more require only a small amount of laboratory work prior to their submission.

MECHANICAL SCIENCES DIVISION

MECHANICAL ENGINEERING RESEARCH

Sampling, Cleaning, Handling, and Shelling of Peanuts. Conducted jointly by the Station and the Georgia Experiment Station under the sponsorship of the Georgia-Florida-Alabama Peanut Association and the United States Department of Agriculture, this project is concerned with efficient picking, transporting, receiving, handling, storing, and shelling of farmers' stock peanuts. Tests on laboratory-scale equipment have been made on the cleaning of peanuts by four different methods: (1) washing and drying, (2) electrostatic separation, (3) air-blast separation, and (4) slope-belt separation. Literature searches have revealed that there is little specific information on this phase of the peanut industry. Results obtained to date indicate that large-volume cleaning of peanuts with high efficiency is possible by application of a combination of the above methods. Field testing of pilot machinery developed and constructed here was begun in July, 1950.

In the future, the shelling problem will be investigated with a view towards the reduction of "splits," and the handling of peanuts will be studied in an attempt to uncover the best methods; the picking problem (shelled peanuts) will also be investigated if time permits. An industrial engineering survey of peanut shelling plants will be made before designing a hypothetical plant.

Peanut Planting and Harvesting Machinery. One project, jointly sponsored by the Station and the Georgia Experiment Station, has as its present objective the further development of the high-speed peanut planter (designed and built in 1948-1949 for tractor operation) which will accurately and rapidly plant seeds uniformly spaced in one or several rows.

Extensive field tests conducted by the Georgia Experiment Station, which has had the planter in its possession since last year, have proved very satisfactory. Tests preliminary to possible commercial manufacture are now being conducted.

Hydraulic Scales. In cooperation with the Georgia Experiment Station, hydraulic scales with a capacity of 1,500 pounds and an accuracy of approximately ± 2 pounds have been developed, primarily for portable use for cattle weighing in the field. Actual use has established the satisfactory performance of these scales, three improved models of which are now being constructed.

Gasoline Engine Development. This project has for its objective the investigation of a nonthrottling cycle for spark ignition engines at part load. The system has been installed on a six-cylinder engine and operates satisfactorily mechanically; improved efficiency was observed. Further theoretical calculations have been made, but experiments based on these have not been completed.

Window Research. Considerable assistance has been given to an industrial sponsor in regard to the design of various windows for strength and low-air infiltration.

Figure 2. Modern agriculture calls for more and better design of equipment. The peanut planter shown above—designed, developed, and built at Georgia Tech—is typical of the engineering design and develpment projects of the Engineering Experiment Station.

Medical Equipment. Several projects for medical schools (particularly that of Emory University) and local physicians have resulted in the development, construction, or alteration of various medical equipment such as a respiratory gas analysis system, a blood sampling device, special magnets, angioroentgenologist stands, and a high-speed motion picture camera equipped with an electronically synchronized motor drive in order to permit photography of a fluorescent X-ray screen.

Automatic Assembling Machine. For a manufacturer, an automatic assembling machine was developed and constructed. Combining nine operations, some simultaneous and some in sequence, the completed machine turned out 60 units per minute, permitting a tenfold increase in production over the previously hand assembly techniques.

AERONAUTICAL RESEARCH

Increasing the Maximum Lift Coefficient of Swept-Back Wings. One project deals with an investigation of several trailing edge flap configurations on swept-back wings, in an attempt to increase the maximum lift coefficient. Tests have indicated a reduction in angle of attack at stall, with some increase in maximum lift together with increased pitching moment. A report on the analyzed and correlated data will be submitted to the National Advisory Committee on Aeronautics.

Studies of the Aerodynamic Properties of Airfoils by Means of the Hydraulic Analogy. The objective of this project (sponsored by the Station) has been the development of the water-table as an instrument for the study of aerodynamic properties of airfoils. Considerable information on the value of the hydraulic analogy to aeronautics research has been obtained. This work has directly contributed to the educational efforts of the Georgia Institute of Technology by providing material for eleven graduate and undergraduate theses.

Effect of Twist and Taper of the Blades of a Helicopter Rotor in Vertical Descent. The purposes of this project, sponsored by the National Advisory Committee on Aeronautics, were the evaluation of the effect of twist and taper of the blades of a helicopter rotor in vertical descent, and the checking of existing vertical descent experimental data on rotors having constant chord untwisted blades.

The analysis of data obtained from wind tunnel tests made last summer revealed certain discrepancies between the results of the present and previous tests. Considerable time was required to discover the sources of these discrepancies, which were found to be largely due to errors in the experimental procedure used in the earlier tests. Several months were then devoted to an unsuccessful attempt to derive a satisfactory theory for the vortex ring state. A final report on this project has been submitted to the NACA.

Wind Tunnel Studies. The objects of several wind tunnel studies have been the determination of the aerodynamic characteristics of airplane components for various aircraft companies.

CIVIL ENGINEERING RESEARCH

Reinforced Brick Masonry. One project, sponsored by the Southern Brick & Tile Manufacturers Association, was concerned with a study of rowlock brick masonry. This type of construction appears to be more economical than the reinforced concrete type because of the elimination of forms, the extensive use of prefabricated parts, and the efficient coordination of the labor force.

For future work, it seems advisable to perform tests on specimens of rowlock walls and on their component materials, in order to determine accurately their strength, rigidity, and resistance to heat and moisture penetration.

HYDRAULICS RESEARCH

Study of Corrective Measures for Excessive Erosion. For a power company, a study was made of proposed corrective measures to be applied to the apron of a dam which had been damaged by flood conditions. Models were constructed and examined under various flow conditions in the flumes of the Hydraulics Laboratory.

Chute Spillway. Models of a contemplated chute spillway were constructed and a

study was made of the flow of drainage waters under various heads. This work was performed for the Georgia State Highway Department.

PHYSICS DIVISION
ELECTRONICS RESEARCH

Propagation Studies of Electromagnetic Waves. The work of this project (sponsored by the Air Materiel Command) has been directed toward an investigation of the effect of atmospheric conditions, such as ducts, turbulence, and subsidence inversions, on the propagation characteristics of electromagnetic waves in the microwave region. An ultimate objective is the determination of the optimum frequency (or frequencies) for microwave transmission over rough terrain.

Valuable microwave propagation data were collected in a series of measurements at 3-, 10-, and 25-cm. wave lengths over a 21-mile path between Georgia Tech and Lost Mountain. Detailed investigations of variations of temperature and humidity with altitude were made with an automatically recording sounding system to an altitude of 100 feet above the surface. Statistical methods of analysis have been used in establishing correlations between atmospheric conditions and received signal strength. It is believed that these results may be of use in evaluating the probable performance of microwave systems, such as those used in long-distance telephone and television transmission, for similar paths of propagation.

Radar Research and Development. Several studies, brought to a successful conclusion

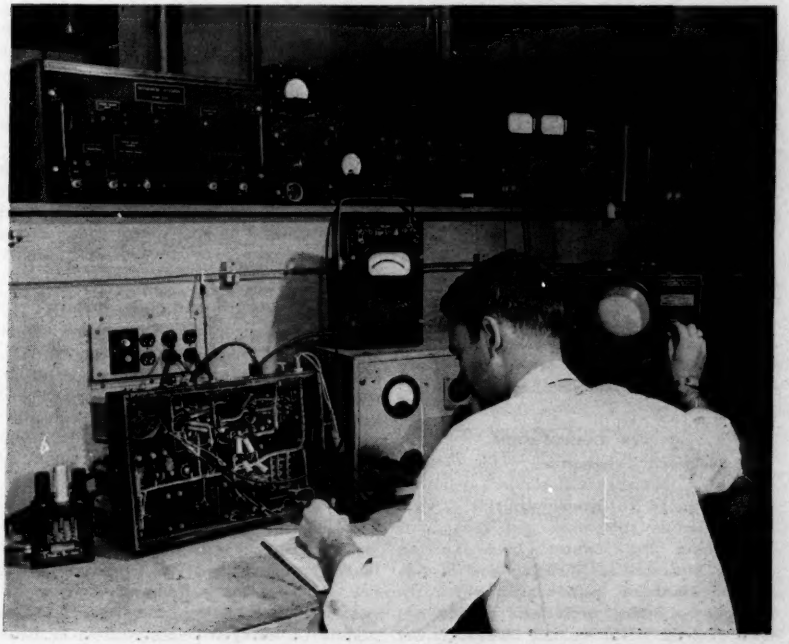

Figure 3. Electrical engineering research at the Engineering Experiment Station has many facets. Above, one of the staff research engineers is shown engaged in the study of a complicated circuit problem.

during the year, have resulted in the development of special radar and related equipment.

High Frequency Crystal-Controlled Oscillator Circuits. The object of this project, sponsored by the U. S. Army Signal Corps, is the development of crystal-controlled oscillators for producing electrical oscillations of very high frequency. Circuits which perform considerably better than those of previous arrangements have been developed. Conditions of operation were analyzed and experimentally confirmed.

Dielectric and Reflecting Properties of Sea Water at Microwave Frequencies. Sponsored by the Station, this project is directed toward a fundamental study of the dielectric and reflecting properties of sea water at frequencies in the 20-35 kmc. range.

TELEVISION RESEARCH

Velocity Modulation Studies. The present purpose of this project is an investigation of the basic principles of television image reproduction by the use of velocity modulation. Previously, investigators have stated that it is impossible to reproduce standard television images by use of velocity modulation. The new principles discovered here in this research, however, may: (1) permit the development of simplified television systems, (2) provide improved clarity in standard television systems, and (3) indicate the possibility of obtaining three-dimensional presentation of certain subject matter (see the cover of this issue). Future investigations will deal with the velocity modulation characteristics of magnetic deflection tubes.

POWER TRANSMISSION

A-C Network Transmission. The Georgia Tech A-C Network Calculator Laboratory has continued to render valuable services to numerous companies and consultants throughout the country. Companies as widely separated as Michigan and Florida have utilized its special facilities for the solution of their problems. During the past year the calculator was used by power companies for 35 weeks, in addition to time in which it was employed on faculty and student research projects.

MATHEMATICAL RESEARCH

Study of Graphical Methods of Calculation. A Station-sponsored project seeks to organize and develop methods of graphical and mechanical computation and to render service to other projects of the Station and to other engineering laboratories in this area in the form of nomographs and special slide rules developed for their particular use. The work of the past year has been almost entirely theoretical. The theoretical background of graphic methods has been greatly extended and simplified, and several papers have been prepared whose publication awaits the appearance of prior material already in the editors' hands. In addition, an intense study of related fields has been under way.

Upon completion of a unique nomographic dividing machine, the construction of very accurate nomographs for certain formulas important in various engineering fields will be initiated, beginning with those in the field of chemical engineering. Further plans also involve promotion of the publication of nomographs.

90° Phase System. The purpose of this project, sponsored by the U. S. Army Signal Corps, was the mathematical analysis of 90° phase difference systems. This analysis has been completed and reported in detail to the sponsor. Experimental equipment is being constructed to test the practicability of the analysis.

ELECTRON MICROSCOPE STUDIES

The Georgia Tech electron microscope was in frequent use throughout the year. Besides work for the Station's projects, studies were made for several industrial and institutional groups on a variety of different materials such as clays, kaolin, pigments, minerals, manganese dioxide, and gold sols.

* * * * *

The State Engineering Experiment Station is an organization devoted to rendering research and developmental service to industry and government, and to science in general, through integrated application of Georgia Tech's research facilities. Every effort will continue to be focused on rendering such service in more and better ways.

PSYCHOLOGICAL TOOLS FOR BUSINESS AND INDUSTRY

By SIDNEY Q. JANUS*

Psychology is by no means an abstract science, as has already been shown in several articles in this journal. The following paper, also, gives ample evidence that "industrial psychology" is no futuristic field, through its discussion of specific psychological tools.

The first half of this century has witnessed a steady growth in man's understanding of man through psychological investigation. This growth has been accelerated sharply by both of the two world conflicts, in each of which the psychological investigation of man received a particular orientation, that of manpower *evaluation* and *utilization*.

No one, today, questions the advisability of the proposition that a careful *assessment* of men should precede the *assignment* of men. In the ranks of top-drawer management, this proposition has been widely accepted, and evidence abounds throughout the South of management's interest in tools which effect the optimum use of every skill employed.

THE APTITUDE TEST

Most often on the lips of personnel directors, yet seemingly the least understood of all personnel selection techniques, is the aptitude test or battery. What is often overlooked is that this device involves a *group* of tests or measures, not just one test; that each test is included in the battery, or group of tests, because of its carefully studied and demonstrated relationship to success in a specific job; that the battery selects those who promise to be rapid learners on the job and is not at all designed to select persons with ready-made skills; that the battery itself must have been tested on a representative sample of already employed workers for whom a measure of job success is readily available; and that the battery is the result of an experimental tryout of many tests, some of which fall by the wayside when the statistician finds that they have no significant relationship to job success.

Thus, personnel directors who select a group of tests hypothetically, or borrow a battery used in a similar plant for a similar job, may be committing a grave error, for those who work with aptitude tests agree unanimously that specific batteries of tests must be tested specifically on a given job in the plant wherein the selection problem exists. Each company must develop its specific norms or "yardsticks" for selection of potential candidates who will succeed on the job.

This is a concept which some personnel directors find difficult to understand, and hence are reluctant to accept. However, one should always bear in mind that even in two similar plants where the same job is being studied, differences are bound to exist in such areas as supervision, working conditions, wage incentives, and the like. Therefore, the criterion of worker-success is likely to vary from plant to plant—and it normally does.

As examples of the use of aptitude tests, one may point to the batteries of tests for clerical workers used by banks and department stores to select rapid learners in bookkeeping machine operation, and to the salesperson test battery used predominantly in department stores. The writer has participated in the development of batteries for the textile industry for such occupations as weaver and burler-and-mender, and is convinced that this research could well extend to cover such jobs as spinner, doffer, and loom fixer.

SINGLE PSYCHOLOGICAL TESTS

Single psychological measures are more commonly used by personnel officers than are groups of tests or batteries. It is much simpler, for example, to purchase a supply of tests to measure mental ability, or mechanical comprehension, than it is to de-

* Professor of Psychology.

velop a specific battery of tests from a specific sample of employed workers. Here, however, lies the danger, for the single test selected may be quite unsuited to the purpose for which it has been chosen. Thus, a commercial airline company found that a mental ability test it was using actually did not discriminate among its applicants since the test was administered on a no-time-limit basis and almost all applicants fell within a rather narrow range of scores.

Such "bunching" may also occur when a test is either too easy or too difficult for the group to whom it is administered. That is why it is so important that tests should first be tested for their ability to do the job of discriminating among workers and measuring what they are supposed to measure. The mere title of a test, *e.g.*, "Test for Mechanical Comprehension," or "Test for Clerical Ability," is in itself no guarantee of what it really does measure. Despite these considerations, the writer has observed many instances in industrial employment offices where hypothetically selected tests are used to measure such attributes as interest, clerical skill, mechanical skill, temperament, and intelligence. Some of these tests are of the paper and pencil variety, where the applicant merely responds to written exercises. Others are of the apparatus type, where the applicant manipulates small parts; coordinates eyes and hands, or eyes, feet, and hands; or exhibits his finger or manual dexterity as the case may be.

To management, the apparatus, or "dexterity board" as it is so often labelled, represents a *concrete* measure as distinct from the *abstract* paper and pencil measure. For this reason, the writer has found it difficult to dissuade management from the indiscriminate use of apparatus tests that appear "on the face of things" to measure "just the thing we're looking for on this job." The only way to prove that this face validity is a deception is to test results against employee-production records, foreman ratings, or any other carefully studied criterion of worker success on the job. Until this is done, the value of psychological tests used singly or in groups must be open to serious question. Equally serious is the limitation of employing only one test for selection, as in the many instances where an interest test is used to select salesmen—as if interest in sales alone were the mark of a successful salesman!

VISION AND HEARING INSTRUMENTS

Industry is today becoming more and more receptive to the proposition that individual differences in vision affect workers' adjustment to their jobs. Thus, a man may be accepted for employment on the basis of a Snellen eye examination and then give evidence after employment of lacking the necessary near acuity for his work. There is now ample evidence to show the obvious economy in testing for specific visual characteristics for specific jobs before employment. That there are adequate visual screening devices available is apparent from a recent paper on this subject by Joseph E. Moore.*

The relative precision of visual instruments does not weaken the argument that they, also, must be pretested on specific samples of employed workers before they can be established as selection tools. As an alternative, of course, follow-up studies may be conducted on persons screened by means of visual apparatus to see how well the instrument differentiates between those who turn out to be superior, average, and poor workers. In any case, however, the visual test is still but one of several potential measures which can be employed for diagnosing skills, potential or actual, for a given job.

Hearing instruments are available which are very carefully designed, much as in the case of optical apparatus. However, considerably less research on hearing has been undertaken than in the comparable field of vision so far as industrial selection and utilization of manpower is concerned. There are some obvious reasons for this. Job requirements are more likely to make visual demands more apparent than those for hearing. Moreover, visual characteristics of the worker are more likely to affect his work output and the quality of

*Joseph E. Moore, "Visual Screening Devices," *The Research Engineer 1949-50*, No. 4, 11-14, 21, 22 (1950).

Continued on Page 24

DIGESTS OF GRADUATE THESES

AERONAUTICAL ENGINEERING

1949-1950

This and subsequent issues of THE RESEARCH ENGINEER will contain digests of theses submitted at Georgia Tech in 1949-1950 in partial fulfillment of the requirements for graduate degrees (usually Master's degrees) in aeronautical engineering, chemical engineering, chemistry, ceramic engineering, electrical engineering, industrial management, mechanical engineering, physics, safety engineering, textiles, and textile engineering. All of these theses are available for consultation in the Georgia Tech Library and in the schools to which they were submitted.

Robert Graham Bodiford, *An Investigation of the Effect of Surface Finish on the Flexure Fatigue Strength of 75S-T6 Aluminum Alloy Sheet.* Faculty advisor: Professor D. W. Dutton.

Flexure fatigue tests were conducted on aluminum-clad 75S-T6 and 24S-T3 sheets of commercial thickness (0.040 inch), both on polished specimens and specimens scratched by various abrasive cloths. The abrasive grades of the latter ranged from crocus cloth to number 60 grit. The magnitude of the depth of scratches was several ten-thousands of an inch.

Curves of applied stress versus number of cycles to failure were plotted, and stress concentration factors for the individual materials and abrasive grits were determined as a function of the number of applied cycles. The range of cycles to failure varied from 10,000 to 10,000,000. A representative stress concentration factor for this range for each material and abrasive was determined.

The flexure fatigue strengths of the materials were compared, both in the polished and scratched states, and conclusions were drawn concerning the relative merits of the different materials with respect to their fatigue qualities.

Eric John Catchpole, *Application of the Hydraulic Analogy to Study the Performance of Two Airfoils in Compressible Flow.* Faculty advisor: Professor H. W. S. LaVier.

Two airfoil profiles were tested in the Georgia Institute of Technology water channel at two flow speeds and over a range of angles of attack. Using two different techniques, photographs were taken of the flow about the models, and from these the water depth distributions along the airfoil profile were obtained. By application of the hydraulic analogy offered by the water channel, the pressure distributions on the airfoils in two-dimensional supersonic gas flow were then determined. These distributions, and the values of lift, drag, and moment coefficients obtained from them by integration, were compared with theoretical and wind tunnel results for the same profiles in air. Good qualitative agreement was obtained, but it was found that refinements in the measuring technique would be necessary if quantitative results are to be obtained.

Charles Buren Cliett, *A Study of Fatigue and Corrosion Fatigue for 24ST Aluminum Alloy Sheet.* Faculty advisor: Professor G. K. Williams.

The effects of the combined action of cyclic stress and a corrosive atmosphere were found to be quite pronounced on 24ST aluminum alloy throughout the range from an applied stress of 45,000 pounds per square inch to an applied stress sufficiently low to allow 10,000,000 cycles of completely reversed stress without failure. Use of an anodizing process on this alloy was found to be detrimental to its fatigue properties; also, the anodizing process followed by painting did not prove beneficial to the corrosion fatigue properties, for it was found that the unprotected alloy has corrosion fatigue strengths above those determined from specimens coated in this manner.

The use of organic coatings as a means of control for corrosion fatigue shows great promise. When a 60 per cent alkyd

type and a 40 per cent urea formaldehyde coating was used, improvements over the corrosion fatigue properties of unprotected specimens were found throughout the range of testing.

Philip Robinson Compton, *An Analytical Procedure for Determination of Lift and Drag Forces for Bodies of Revolution.* Faculty advisor: Professor H. W. S. LaVier.

A study of some of the very extensive theoretical work which has been conducted on the flow about bodies of revolution, coupled with an analysis of very recent experimental results suggested an analytical procedure which successfully predicted the observed drag and lift forces on various shaped bodies of revolution.

The analytical prediction of drag was based upon test conditions conducted over a range of Reynolds Numbers from 214,000 to 2,800,000, and no difficulties were encountered with the supposition that the drag coefficient is not a function of Reynolds Number. Either this range has not included the transition flow from laminar to turbulent, or the variance of the drag coefficient with Reynolds Number is not great on either side of the transition range for bodies of revolution. Drag predictions were within ten per cent of the available test values, which ranged from zero to nine degrees of angle of attack for the various bodies of revolution.

The predicted values for lift were similarly accurate over the same range of angles of attack and indicated a tendency to converge upon the test values as though this solution were very similar to some form of a series function; further investigation should be made for a possible series type of solution as a method of analytical prediction.

Noah Carroll New, *The Aerodynamic Equilibrium Equations of the Lifting Rotor.* Faculty Advisor: Professor Walter Castles, Jr.

The aerodynamic equilibrium equations for a convertaplane rotor were developed and solved for the mean coning angle, over-all blade pitch angle, and cyclic pitch requirements necessary for steady flight. The equations obtained differ from those of previous theories in that their applicability is independent of the magnitude of the inflow angle at a blade element, Φ since the usual approximation that Φ is a small angle was not used. Instead, the more accurate assumption was employed that the blade element angle of attack, a, is a small angle.

Charles L. Seacord, Jr., *Determination and Classification of Airplane Transfer Functions.* Faculty advisor: Professor D. W. Dutton.

A theoretical investigation has been made of airplane transfer functions. The airplane configuration chosen for analysis was typical of modern high speed aircraft. Its stability characteristics were expressed in terms of nondimensional parameters, thus making the results obtained applicable to aircraft of any size.

These stability parameters were substituted in differential equations of motion, and the response of the airplane as a function of the driving frequency was obtained by use of the operator $D = i\omega$; the derivation of this method is presented in detail. Calculations were made to determine the response in the following quantities: pitch angle, angle of attack, flight path angle, normal acceleration, roll angle, and yaw angle. Results obtained are presented in the form of frequency response curves and transfer function curves for the various quantities. The responses in pitch angle, angle of attack, and flight path angle were calculated for a range of airplane inertia values.

Gerald B. Thomas, *Application of Water Channel Compressible Gas Analogies to Problems of Supersonic Wind Tunnel Design.* Faculty advisor: Professor H. W. S. LaVier.

A water channel and small supersonic wind tunnel of the blowdown type were used to determine the applicability of the hydraulic analogy to compressible gas flow in the design of supersonic nozzles.

A model of a portion of the two-dimensional supersonic wind tunnel was tested in the water channel, and, by use of the hydraulic analogy, the pressure distribution along the model was obtained for comparison with pressures measured in the wind tunnel. Pictures were taken of the water flow in the nozzle and compared with Schlieren photographs of the air flow in the wind tunnel nozzle.

The results obtained show good agreement between the water channel flow and that of the wind tunnel. Local variations

of contour which resulted in disturbance of the flow were observed in both models; improved flow was obtained by modification of the contours. These experiments demonstrated the applicability of water channel testing of wind tunnel shapes as a preliminary step in the design of supersonic wind tunnels.

MILITARY RESEARCH

Continued from Page 2

food preservation, textiles, electronics, etc.

Groups such as the Georgia Tech Engineering Experiment Station recognize full well that their unique combination of facilities and technical talent render them unusually fitted to engage in many studies directly or indirectly related to the national security. In return for their cooperation with the Armed Forces, they receive the benefits which devolve from gaining additional experience, the further enlargement of facilities and staff, and — by no means least — the very real knowledge that they are doing their share to render this nation scientifically and technically prepared for what may come.

TELEVISION TODAY

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poorer audio fidelity and degraded picture resolution. On the credit side is the fact that new sets now employ the larger, filter-glass kinescopes, which have improved contrast and may be viewed by larger groups.

The reduced resolution of these new sets can be tolerated because a large percentage of the present television programs recorded on film or transmitted over the coaxial cable do not contain fine details. It is to be hoped, however, that as the technical quality of the programs improves, manufacturers will again make receivers which will utilize the full capabilities inherent in present television standards.

In the field of large sets, General Electric has recently announced the production of a 24-inch, direct-view picture tube, and DuMont is putting a 30-inch tube into production. RCA has manufactured several theater television projection systems which have been successfully employed in New York and other cities.

CONCLUSION

Television has much to offer for the good of society, and scientists and engineers have a degree of responsibility in seeing that this new medium is not misused for the sake of immediate profit. There is fear in some circles, for example, that television will mean doom to radio broadcasting, the motion-picture theaters, and sports events. In reality, while television will certainly affect the established order of things, it may well actually stimulate these activities in the same manner that radio eventually bolstered the phonograph industry.

It seems clear that the three-billion-dollars-per-year radio and television manufacturing industry is a great boon to our economy in peacetime. Moreover, if this country should really have to prepare for all-out war, in which vast quantities of electronic, radio, and radar equipment would be required, it is comforting to know that the radio and television industries can rapidly convert their plants to produce this equipment.

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PSYCHOLOGICAL TOOLS FOR BUSINESS AND INDUSTRY

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his performance, as well as his personal adjustment, while hearing characteristics appear primarily to involve the personal welfare of the worker. However, there is increasing evidence which points to the advisability of checking on the amount of hearing loss, if any, that an individual has suffered before he is employed. While this is obviously important for jobs in communications, for instance, it is also quite important for any other occupation where auditory stimuli are involved in the worker's effective responses to his environment.

INTERVIEWING TOOLS

Although tests have now gained wide acceptance in some industrial circles, there is no evidence whatsoever that they will ever supplant the interview as a personnel tool, for an interview remains the sole basis for a face-to-face relationship where both management and the worker can "size" each other up in a spirit of give and take. But proper interviewing, however, is an art that requires considerable training. All too often the writer has come up against the presumption that anybody, just anybody, can ask questions and hence can be an interviewer. However, human beings, like nature, will give clear-cut answers only when clear-cut questions are put to them. For this reason it is encouraging to see more and more evidence of the use of predetermined and pretested questions in employment offices during the interviewing process.

The writer has observed several instances where oral trade questions are effectively used in personnel selection. These are questions designed to discriminate among applicants who are either journeymen, apprentices, or complete novices in a craft or trade. Such questions are based on the assumption that if a person has had experience in a job he can readily answer some carefully standardized questions relating to his tasks. The converse is not true, however. Mere knowledge of and about the job does not guarantee that the individual possesses the skills. In every case, the individual's work history should be brought to bear as substantiating evidence. Nor should the interviewer neglect to develop his own judgment simply because he has before him a sheet of prepared questions.

Some companies have found it useful to assign more weight for some parts of the interview or application blank than for other parts in obtaining the total assessment picture. These weights can be studied systematically and assigned numerically to the several items comprising the interview blank or record. Here again, however, neither oral trade questions nor weighted items in an interview can be effective unless they have been put to the test of their discriminating power and their ability to measure what they have set out to measure, and unless, further, they can do these jobs consistently from day to day, from applicant to applicant.

Exit interviewing should also be mentioned under this heading, since it is an important diagnostic tool for the interviewer. This genre of interviewing aims at discovering causes underlying worker unrest or dissatisfaction. As its name implies, it is a terminal process occurring when the worker has decided to leave his position. Nevertheless, exit interviewing has sharply delineated implications both for practices affecting persons to be acquired through future employment and recruitment and for those remaining within the labor force. The writer is convinced that a careful examination of exit-interview records will repay the effort involved.

Psychological tools for business and industry are now firmly established implements for use in scientific employment. Their proper use more than repays the effort required for their specific selection and application.